TOPOGRAPHY

OF THE

PUNJAB OIL REGION.

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ARTICLE I.

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I.—SITUATION.

The Punjab oil region is in the corner between Cashmere and Cabul, and lies wholly between north latitude 32° 31′, and 33° 47′, and east longitude (from Greenwich) 71° 18′, and 73° 5′; a nearly square space about a hundred miles long east and west, by ninety miles wide, north and south.

Just inside the northeast corner of this square is Rawul Pindee, the largest town of the region, with about twenty thousand inhabitants; just inside the southeast corner is Pind Dadun Khan, a town of about twelve thousand inhabitants; and just inside the southwest corner is the ancient uninhabited ruin of a walled town, now called Kafir Kot. Just within the northwest edge of the region, and less than twenty miles from its eastern edge, stands the little village of Shah kee Dheree, on the site of the ancient capital

Taxila, where the king Taxiles hospitably entertained Alexander the Great. The small town of Attok, where Alexander crossed the Indus into India, is only ten miles north of the middle of the northern edge of the square. The famous Muneekyala Tope, built by king Kanishka, about the Christian Era, to mark the spot where Booddha in compassion gave his own flesh to satisfy the hunger of a starving tiger, stands a little outside the square, fifteen miles southeast of Rawul Pindee.

The River Indus enters the square about the middle of the northern edge, and leaves it at the southwest corner. The Jhelum River (the "fabulosus Hydaspes" of the ancients), one of the five rivers that give its name to the Punjab, flows across the southeast corner, past Pind Dadun Khan, southwesterly towards the Indus. The centre of the region is drained by the Sohan, which rises near Rawul Pindee, and flows west southwest to the Indus.

The region lies, then, mostly between the Indus and Jhelum, in what is called the Sind Sagur Doab (two rivers), and it is mainly in the mountainous or hilly part (Kohistan) of the Doab.

II.—GENERAL LAY OF THE LAND.

The wide, flat plain of the lower Indus skirts the southern edge of the region, but the rest (within the Doab) is filled by a somewhat uneven table land, about 750 feet higher than that plain, with the Salt Range on the south in a very open vee, pointing southwesterly, and long armed on the east, and with the Choor Hills and a spur of the Himalayas on the north, nearly parallel to the Salt range, but in a still more open curve, and with two or three much shorter parallel mountains between those two main ranges.

This spur of the Himalayas (4,000 feet high above the sea) just enters the northeast corner of the region, dies down into the plains (about 1,900 feet above the sea) for a dozen miles, and is continued westerly in the Choor Hills (up to 3,500 feet in height) as far as to the Indus, followed by a little studied region of higher mountains, west of the river. The Salt Range, with two ridges 3,000, or even at one point 5,000 feet high and a valley between of half a dozen miles wide and some 2,500 feet high, passes just north of Pind Dadun Khan, west and southwesterly, to the southern edge of the region, and then turns northwest with a single ridge, and afterwards with several ridges, to the Indus, followed by high mountains west of the river.

The country between the Choor Hills and the Salt Range is a comparatively level one, about fifteen hundred feet above the sea. A dozen miles southwest of Rawul Pindee, the mountain called Khairee Moorut rises above the plain, and runs southwest for fifteen or twenty miles, reaching a height of over 3,000 feet. There are also, here and there, a few lower hills in the plains.

On the south the Salt Range falls abruptly to a very level plain that spreads far and wide at about 750 feet above the sea. In the very southwesternmost corner of the region the mountains west of the Indus come close to it at Kafir Kot, and run southerly with a double ridge, and rise to a height of more than 2,000 feet above the sea.

The Indus flows with a swift current through a narrow, rocky channel (100 to 500 yards wide) with high banks in the country above the Salt Range, but on reaching the plain below (at Kalabagh) spreads out into many wide channels, with low banks and irregular islands, and changes its course from time to time. The river falls between Attok and Kalabagh (110 miles) about two feet a mile; for 350 miles below Kalabagh about eight inches a mile. The Jhelum likewise spreads out into many channels in the low country.

As the climate affects the topography, it must be remarked that almost all the rain of the year takes place, in this region, within two or three months of the summer, which are preceded by two or three months of very hot, dry weather, with the thermometer sometimes at 120° F. in the shade. Owing to the summer rains and the melting of snow in the Himalayas and other very high mountains, there are great floods, and the Indus rises about fifty feet in the narrow channel above Kalabagh; but in the wide channels below, about eight or nine feet, spreading out into broad lakes. The stream of the Sohan, and other smaller rivers is, in the dry season, a mere thread in the midst of a waste of sand sometimes a mile or more wide, which it wholly covers in the rainy season. Of course many of the smallest rivers are quite dry before the rains begin. The streams that flow down the southern face of the Salt Range almost all dry up in the great heat of the low country, and are lost in the sand before reaching the great rivers.

In the valley on top of the Salt Range is a lake, Son Sukesur Kuhar, that has no outlet and is salt. On the northern side is another salt lake, Kullur Kuhar, which has, however, an outlet in high water, and is less salt than the other.

III.---SPECIAL FEATURES.

In looking into the topography of parts of the region, the chief things to notice will be (1) their general height, (2) the character of the hills as affected by the steepness of dip of the rocks, (3) the modification of this character with time, and (4) the mode of cutting out the valleys.

1. The most striking feature in the topography of any region is the general difference of height of the different districts. We have, for example, in the region in question, mountain lands, such as the Salt Range, the Choor Hills, the Himalaya Spur, and Khairee Moorut; table land, such as the central part of the region; and low land, such as the plain south of the Salt Range.

The causes of such present differences of height are: the height to which the rocks have been raised to begin with; the length of time that they have been wearing away; and the general ease with which they wear away, which depends on their general hardness, firmness, solubility or permeability. The final result of the wearing away; that is going on all over the land is, of course, to bring everything to a dead level, and that the level of the sea. It might therefore be that land as high as the Kohistan once stood south of the Salt Range, and has in the course of many ages been worn down to a low, flat plain; as in the course of time the Kohistan must be, if it should never be pushed upward again. But the low land, south of the Salt Range, is still high enough above the sea to show by unequal wearing away harder ribs of rock, if it had them; and it would seem to be pretty uniformly soft to some depth, as if not long enough deposited to become very hard. It is probable therefore that since the deposit of its present upper surface it has never been raised so high as the Kohistan, though this surface may rest upon a floor of much older rocks below, that may be the remnant of land as high as the Kohistan.

The whole of the Kohistan, however, seems to have been raised about the same time and to about the same height; and its differences of level come in a great measure from the relative ease with which its rocks have been worn away, chiefly from their relative hardness. But the table land has been in general wearing away for a much less time than the mountain land, because it is made up of newer rocks that were formed in the bed of what was perhaps a great lake in the older rocks that make up the mountains. The newer rocks, then, take the place of a great hollow in softer rocks of the older formation, a hollow that would have been worn still deeper but for the protection that has been afforded by the covering.

This consideration enables some conclusions to be drawn as to the geology from the mere topography. The Salt range is formed chiefly of a thick lime rock (the nummulitic) and the softer rocks that it covers; and the Choor Hills Range consists of a similar probably the same lime rock; and Khairee Moorut most likely of the same; in short all the high mountain land of the region seems to be caused by the presence of this thick lime rock, and it is probable that wherever it once rose above the present level of the country it has left hills or mountains to mark its place. Now, the dip on the northern side of the Salt Range is northerly, and it is pretty certain therefore that the Southern dip of the Choor Hills must be southerly; for, if this were northerly, the lime rock must have risen to the surface somewhere between the two ranges, and have left a ridge of rocks dipping southerly. Khairee Moorut is too short to represent so long a ridge as this must have been, and is probably a small saddle of the lime rock rising above the table land. The rocks, then, south of the Choor Hills, as at Gunda, must rest upon the lime rock of

those hills, however much steep and even somewhat reversed dips may make the contrary seem probable. The apparent dips did indeed mislead me at first. But if the Choor Hill lime rock lies really above the Gunda rocks, then both must be above the Salt Range Nummulitic lime rock; and this is possibly so.

2. Looking closer than at the mere height of the land, the forms of its surface have three different characters according as the rocks (*a*) lie level, or (*b*) dip steeply, or (*c*) gently.

a. The central table land of the region is mainly made up of rocks of quite late age, perhaps old alluvium, possibly passing without break into Siwalik (Miocene) rocks below. These rocks lie nearly or quite level, and this fact here, as in other regions, gives rise to characteristic forms. The general slope of the country is comparatively level, and the ground is generally flat; but near the streams, high vertical cliffs are common, connecting the flat tables above with the flat valleys below. This might be called square-edged topography. The rocks are generally pretty soft or tender, some of them especially so; and the growth of a narrow gully into a good sized valley is quite rapid.

b. The surface of this part of the region is not, however, exclusively of this square-edged character, for it is somewhat affected by the older rocks below, which rise to the light in many places both in the valleys and on the higher lands. These rocks are of nummulitic age and are generally harder and firmer than those above, and often remain standing where they may have once been covered by them. In the northern part of the region the lower rocks generally have also a steep dip, and are folded into numerous sharp saddles and basins. This makes it not uncommon here for harder layers of rock to stand up like a knife edge, so sharp, in fact, that some of the Cheerpar hills, 150 feet or more in height above the plains, are so thin as to have holes and long horizontal slits quite through them at some distance from the top. Such topography might be called sharp-edged. Owing to the great exposure of the softer layers to the falling rain, they have been much worn away, so as to leave the harder ribs standing out, and the topography has a skeleton-like, bony look. This fact often enables the geological structure to be seen very easily from the mere topography, and the basins and saddles to be made out from the map. The topography has this sharp-edged character, in places where the streams have cut down to the lower rocks, as far south at least as the Sohan River. It is shown by the little, sharp, narrow, parallel valleys of the small streams that empty into the Sohan on the north. It is probable that the same sharp folding of the lower rocks continues for some distance south of the Sohan; but the map shows no such sharp-edged topography, owing no doubt to the thick covering of the newer rocks above, as far as to the Salt Range.

c. In the Salt Range part of the region, the nummulitic rocks rise very high, generally

in a double saddle with a small basin between, but have commonly pretty gentle dips, especially towards the north. Sometimes the dip is so gentle as to give rise to something like the square-edged topography already noticed; for example, at Chinnoor, Hungooch and Dooma. But the dip is often too steep for this, and the topography is then blunt-edged in character, as in the hills northeast of the Salt Range at Jaba near Kalabagh and many parts of the Salt Range itself. There are even in this case often short vertical cliffs, but the shape of the land above them is steeper than where the rocks lie level, though less steep than where the rocks dip very steeply. At Aluggud there is a very uniform dip of about 25°, and a nearly corresponding steepness to the hill on one side; but certain soft thick layers of clay or shales are so protected by harder layers of sand rock or lime rock as to form vertical walls on the other side of the hills. Had the dip been much steeper, the clay and shales would doubtless have been wholly washed away to water level leaving the harder sand rock and lime rock layers standing, if these were thick enough to hold themselves up.

3. The progress of the wearing away with time gives rise to varieties of these main topographical characters. The tendency is to bring the whole country finally to the level of the sea; but progress towards this end is, of course, more rapid in the water courses than elsewhere. Little elevation above neighboring drainage levels by lessening the force of the streams makes the progress slower.

We have, therefore, in a square edged district, first, flat land with crooked, meandering, almost aimless streams, as shown in the low country south of the Salt Range and perhaps in some patches north of Nummul and elsewhere, as well as along some large streams. Next the country becomes uneven; and if the surface to some depth is uniformly soft, the land becomes rolling, as perhaps in some large patches north of the Salt Range; if the surface is somewhat harder, it will so last and shelter the rocks below, as to give rise to long cliffs and gorges, as near Chinnoor, Hungooch and Dooma and elsewhere along the northern side of the Salt Range, and at Nursingpuhar and other places on the southern side. In the course of time, however, after the streams have cut down to their lowest level, these cliffs must recede farther and farther from the streams, though at length with great slowness, and finally the whole country becomes again a dead level, if it remain undisturbed long enough.

But where the rivers, as in the higher country, flow among rocks that have a decided dip, their direction is of course much influenced by the strike of the rocks. It is very plain, for example, that the Sohan follows in general the strike of the lower (nummulitic) rocks; and the same may be said of many of the smaller streams, especially of the very striking series of small side streams of the northern feeders of the Sohan.

In a district where the rocks dip gently, their basins, as they are wider than in one of

steep dips, are likely to be longer also and less decidedly broken up by subordinate folds and the saddles between less broken up and crushed together. The valleys are therefore more likely to be long and the ridges unbroken; and in the course of time, after the first irregularity caused by the comparatively quick wearing down of the main channels to their lowest level, there becomes great uniformity in the shape of the valleys, long, narrow, and parallel, and in the crests of the mountains long and level. The valleys form ravines rather than gorges; for they are not extremely steep on both sides for any great distance. The mountains about Aluggud show these features well. Such mountains in wearing away to the final dead level will become more and more gently rounded ridges, the country will become more and more open, and at length quite flat.

Where the rocks, however, dip very steeply and have been much crushed together and overturned the small basins are more likely to vary the drainage of the large ones, there are more chances of cross breaks and numerous cleavage planes; so that the valleys are shorter and more irregular, and the mountains rise in peaks rather than in long crests. So it is in the spur of the Himalayas, in the Choor Hills and in the western end of the Salt Range about Jaba near the Indus. In wearing away, such peaks may become more and more rounded, until they sink to the level of the valleys, and the country becomes flat.

4. The topography is somewhat affected by the nature of the wearing agent, whether this be the wind, (*a*) the rain, (*b*) rivers, (*c*) the sea, (*d*) frost, or (*e*) ice. But no part of this region would seem to be affected materially by the wearing or carrying power of the wind, unless it be some very light, sandy portions of the low country south of the Salt Range.

a. The rain of course falls equally on the hilltops and on the plains, and loosens more or less of the rocks or earth it falls on, according to their hardness, and carries the loosened particles with it to the streams and towards the sea, more or less according to the steepness of the surface. Where a harder bed covers a soft one, this will be, as already remarked at Aluggud and elsewhere, cut to an upright wall around the edges of its shelter. The action of the rain is, then, that of washing. Its effect can be seen everywhere through the region.

b. The action of rivers on the other hand is not merely that of washing, in the same way as rain, but of undermining; for a stream often washes away the bottom of a cliff, and lets the upper part fall by its own weight. It may then wash away the rubbish formed by the fall and continue its attack on the cliff. Such undermining may be seen in progress a quarter of a mile below the Burra Kutta Oil Springs, where the brook has formed at the bottom of the cliff a low cavern not yet deep enough to make the rocks above fall down. A stream that falls over a bed of rock will often, as is well known,

undermine it, especially if there be a softer layer of rock at the bottom of the fall. The undermined edge of the fall at length comes down, the rubbish is washed away, the undermining goes on again, and so a gorge is gradually formed below the fall. A gorge or pair of cliffs facing each other is, then, a mark of river action; and this is generally combined with the action of rain. Such a gorge is to be seen still forming on a small scale at the Chhota Kutta Oil Springs and a few hundred yards above them, although the greater part of the work was done long ago. Gorges formed in the same way are to be seen at Nursingpuhar and elsewhere along the southern face of the Salt Range; they have apparently been made by much larger streams than now flow through them.

The Salt Range has in the western arm of its vee, near its point, at the village of Nummul, a right angled bay in its south-western face; and it looks as if this had once been the outlet of all the waters north of the range, and as if there had been an enormous Niagara here that had begun to cut a gorge below for itself, before the present gorge of the Indus at Kalabagh was cut. Perhaps the great amount of salt in thick layers in the mountain near Kalabagh by its readily dissolving and possibly letting the rocks above become undermined, hastened the completion of the gorge and gave it the start of the one at Nummul.

c. The wearing action of the sea is almost wholly by undermining the headland of a coast. The waves dash against the shore and wear it into a cliff, undermine the cliff, the tidal currents carry off the rubbish that falls, the undermining goes on again, and the sea at last cuts the land down to its own level. But in bays the force of the waves is lessened the water is quieter, the earthy matters in the water drop more readily to the bottom, the rivers bring in such matter from the valley at the head of the bay, and this becomes silted up. A single long cliff or line of cliffs looking down on a wide plain is, then, the mark of sea cutting. The southern escarpment of the Salt Range, so abrupt and striking, gives the impression of a coast line formed by the sea; and really seems to have been so formed when the low land to the south was under water, either salt or fresh, though perhaps a little rounded by the rains since then.

d. The frost, as everybody knows, acts by freezing the water in the small cracks or pores of the rock, and so by expansion loosening particles or masses of rock or breaking them apart, and letting them fall, as soon, at least, as the ice that may still unite them melts away. Such loosened masses could only fall down a pretty steep slope. It may be that this action of the frost takes place sometimes, though rarely, in this region; but it cannot happen often in so hot a climate.

e. For the same reason, there is no sign whatever of the action of ice or glaciers, with their grooving and polishing of the rocks by the pebbles and mud they push along, and with the heaps of rubbish that they leave behind when melted.

It is plain from what has been said that, as the topography is so far from being accidental and is so thoroughly modified by the nature and position of the rocks according to simple laws, its careful study is of the greatest importance in making the geology clear; even if not quite so indispensable for the general geology of a large region as for the geological details of a small tract. A merely shaded or hachured map shows some of the geological facts along with a part of the topography, but is very indefinite and imperfect and insufficient for both, as compared with a contour line map. Such work may sometimes seem too laborious and time taking, but is after all so necessary as to be worth the trouble.

IV. ROCK GROUPS.

The geology of the region or of large parts of it has been treated of by Dr. W. Jameson (Journal of the Asiatic Society of Bengal, 1843), Dr. A. Fleming (Jour. As. Soc. Beng., 1848 and 1853), Mr. W. Theobald, Jr. (J. A. S. B., 1854), Mr. A. M. Verchère (J. A. S. B., 1866—67); and as far as it relates to the oil has been discussed in my own "General Report on the Punjab Oil Lands, Lahore, 1870." Mr. A. B. Wynne, of the Geological Survey of India, has spent the two last winters in exploring the Salt Range and mapping its geology, but beyond a paper or two on special places in the "Records of the Geological Survey of India," his observations have not yet been made public. To save the trouble of turning to those works it may be worth while to give here a short sketch of the geology, so far as known, aside from the structure, which has been already described.

The old alluvial rocks that have been mentioned as covering much of the table land are of unknown thickness (more than fifty yards at any rate), and perhaps pass upward in some places without interruption into the newest alluvium or wash. It is also possible that in places they pass downward without interruption into the rocks that have been called Sivalik.

We have then this general section of the rocks of the region:

		Thickness.
New, little disturbed rocks:		
	Alluvium, or wash.	unknown.
	Old Alluvium? perhaps much more than	150 feet.
Older rocks, with more or less steep dips:		
Miocene?	Greenish gray sand rock, shales and pebble rock and red and green clays (Sivalik? Aluggud and table land north of Salt Range); by some called 10,000 feet, perhaps not more than	3,000 feet
Eocene.	Gunda rocks; light brown and red sand rocks and shales with some grey lime rock and shales (south of Choor Hills) with *oil.*	850 "

	Nummulitic lime rock (Jaba and Salt Range generally) with *oil.*	1,100	feet.
Mesozoic.	Green sand rocks and shales, cherty lime rocks, and iron stained sand rocks with bituminous shales; perhaps -	700	"
Carboniferous.	Lime rock, grey sand rock and shales, calcareous sand rock and shales, about - - - - - -	1,800	"
Devonian.	Red variegated grits and clays with copper; greenish sand rocks and shales with grey dolomitic sand-rock; red sand and pebble rock; and red marl with rock-salt and plaster, say - - - - ; - - -	2,850	"
		10,450	feet.

The three lower formations are in this region found only in the southern part of the Salt Range and about Kafir Kot; and this account of them is gathered from the older writers. But their statements disagree very much; and the age of different beds often seems to have been determined from quite a small number of their fossils. Mr. Wynne's study of these formations has no doubt added much to what was learned about them nearly twenty years ago, and his report will perhaps change some of the estimates of thickness or of age. There would seem to be a good deal of variation in the beds from place to place within short distances.

V. USEFUL MINERALS.

The following useful minerals are found in the region in greater or less quantity :— (1) oil, (2) salt, (3) plaster, (4) sulphur, (5) alum, (6) saltpetre, (7) coal, (8) gold; and in minute quantity ores of (9) copper, (10) iron, and (11) lead.

1. *Oil.*—The oil has been bored upon at Gunda, and at first fifty gallons of it a day were pumped from the well; but the yield of course, grew quickly less (like the ordinates of a parabola), and after the whole amount had reached two thousand gallons (about five months) the daily yield was less than ten gallons. In the region, oil flows also at five other places from natural springs, from a gill to three quarts a day, and there are traces of it at yet two other places, making eight in all. Asphalt, or dried oil, is found in small quantities at four of these places, and at four other places, at two in notable quantities, At most of the asphalt places there are traces of rock tar or asphalt melted in the heat of the sun; and at one of them (Aluggud) as much as 100 gallons. Besides these dozen places where oil or asphalt is found there are half a dozen places where there are small traces of one or the other, enough to attract notice in the minute examination of the country by its inhabitants. About half of all the places are in the north-eastern corner of the region; about half towards the south-western corner; and one or two in the north-western corner towards the middle.

The Aluggud oil (now dried to asphalt) seems to have come from rocks of carboniferous age, to judge by their fossils, though other things would rather show that they were of later age. If they are carboniferous, then the nummulitic rocks are wanting above them, and have thinned completely away from a thickness of 2,000 feet only thirty miles distant. This oil is also the only case of oil outside of the older tertiary rocks anywhere in the whole region.

All the other oil springs or shows of oil in the southern part of the region are on the northern side of the Salt Range and in the nummulitic lime rock or close above it. The northern ones are either in the nummulitic lime rock of the Choor Hills, the same probably as that of the Salt Range; or in the Gunda rocks (chiefly sand rocks) that lie south of them, also accompanied by nummulites.

In every case the oil seems to come from a deposit of very small horizontal extent, sometimes only a few feet, seldom as much as a few hundred yards; only in one case, that of the Chhota Kutta and Burra Kutta oil springs, near Jaba, does the deposit seem to extend as much as half a mile. Here, too, the oil comes from a thickness of about a hundred feet, and the natural springs yield at one place as much as three quarts a day. At all the other places the oil comes from a much smaller thickness of rock, from forty feet at Aluggud and twenty at Gunda and Punnoba downwards. Scarcely do any two oil springs come from the same bed of rock.

The oil is dark green in color, and so heavy as to mark 25° of Beaume's scale, or even less. The Gunda oil has been burned a little by the natives with a simple wick, resting on the side of an open dish; but the Punnoba oil is more inflammable, and needs a special tube for the wick, though the main opening of the dish or lamp may stay uncovered. The oil generally, however, has been little used for burning except at Punnoba; but has been sought for as a cure for the sore backs of camels. The asphalt was also highly prized forty years ago by the natives as medicine, taken in pills, especially for broken bones. It was carried far and wide, and was called "negro's fat," because it was generally believed to have dripped from the brain of a negro that had been hung up by the heels before a slow fire.

It is perhaps needless to say that there is nothing whatever in the mode of occurrence of the Punjab oil, to uphold the chimerical belief that rock oil ever passes by distillation, emanation, or otherwise, from one set of rocks to another, that it originates in any different rocks from those in which it is found; and nothing to show that it has been formed by any other method than the very natural and sufficient one of the slow decomposition of organic matter, deposited along with the other materials of the rock. Neither is there anything to show that the oil has been driven by the upward pressure of water, from the lower parts of a bed of rock through its pores to a higher part of the same bed; on the

contrary, as the rocks near most of the oil springs dip pretty steeply, if such an action of water were possible, all the oil would long ago have been altogether forced out of the rock at the outcrop. Indeed, such an idea is quite inconsistent with the fact that even a slight amount of oiliness in the pores of a body is a complete bar to the entrance of water; much less could water (without soap) scour the oil from one mass of rock and make it flow into another mass filled with moisture. If oil wells are more numerous in some regions along the tops of rock saddles, the reason is clear, that the oil-bearing bed lies too deep for boring conveniently elsewhere.

Wild hopes have sometimes been entertained that a large amount of oil might by boring near the oil springs, be struck in some cavity below the oil-bearing bed; but it is safe to say that they are not justified by anything whatever, either in the Punjab or in any other part of the world, either in the practical experience of oil boring or in the general laws of physics.

2. *Salt.*—In the lower part of the Devonian rocks there are large deposits of salt from white to brick red in color, in layers of about two feet thick, separated by thin (half-inch) layers of red marl, amounting in all to a hundred feet or more. It is mined especially at Keora (in one place in a chamber thirty or forty feet wide and high), and at other places near Pind Dadun Khan, and on both sides of the Indus near Kalabagh. There are other like deposits of salt, perhaps of the same age, west of the Indus, twenty-five miles north of Kalabagh.

3. *Plaster.*—Gypsum is found in beds as much as thirteen feet thick or more, and in thin seams in the Devonian salt marl in the Salt Range, especially near the salt mines; and is commonly light gray and mottled in color, sometimes pure white, pink, brown or greenish, sometimes crystalline. It is also found in a mass of perhaps 20,000 tons at the Chhota Kutta oil springs, and in one of perhaps 200,000 tons near the Punnoba oil springs, and in some quantity at Loone kee Kussee sulphur pits opposite Dundee on the Indus; in each of these cases apparently altered from lime rock by sulphur springs; and there may be other similar deposits in the region.

4. *Sulphur.*—In each of these cases the gypsum is associated with sulphur, which was dug in some quantities twenty years or more ago, from small open pits, and afterwards separated from earthy impurities by sublimation. It is said to have been visible in small yellow particles in the earth, but cannot now be seen in the rubbish of the old pits. There are other sulphur pits near Nakbund west of the Indus, and perhaps elsewhere in the region.

5. *Alum.*—Alum shales, which are also bituminous and pyritous, are found in the Eocene rocks of the mountains near Kalabagh, and are largely mined. They are burned six or eight months in kilns thirty or forty feet high, and leached in vats of baked clay;

the liquor is boiled in iron pans and mixed with "jumsan" (a mixture of sulphate of soda and salt, an efflorescence on the soil in many parts of the low lands), and left to settle and crystallize in vats; the crystals are washed with cold water, and melted in an iron pan in their own water of crystallization; the liquid is poured into earthen jars where it crystallizes and finally the uncrystallized portion is poured off, the jar is broken apart, and the alum is ready for sale. About twenty years ago its manufacture amounted to more than 400 tons a year; and it had been carried on by one family for eight generations.

6. *Saltpetre.*—Saltpetre is said to be leached from black soil at several places a dozen or twenty miles south-west of Kalabagh on the west side of the Indus.

7. *Coal.*—Thin beds of brown coal, with the look sometimes of good bituminous coal, are found in the Eocene rocks of the Salt Range, especially near Pind Dadun Khan; and in the alum shales of Kalabagh. These last beds of coal are very thin and irregular; but the others sometimes reach a thickness of two feet towards the east, and one of them becomes even three feet thick with good coal at one point fifteen miles northeast of Pind Dadun Khan. The beds, however, would not seem to keep of one thickness for any distance, and are on the whole of little value.

8. *Gold.*—Gold has been washed from the miocene sands along the Indus, near Mukhnd and elsewhere; and is found in almost invisible scales. Towards the headwaters of the Indus the scales are said to be much larger. Thirty years ago there were about 300 gold washers between Attok and Kalabagh, and each one earned about ten cents a day. They used a pick, shovel, sieve, cradle, wooden platter (for panning out) and quicksilver. The gold on the Indus is said to be somewhat whiter than that found further east. The washings are richest after heavy rains, that bring down fresh sand from the neighboring rocks to the brooks.

9. *Copper.*—Small concretionary balls of copper ore, chiefly sulphuret of copper (copper glance), commonly covered with green carbonate of copper, from the size of a walnut down, are found in the upper part of the Devonian rocks of the Salt Range; but no vein of the ore has been discovered. The ore is thought to contain from twelve to twenty per cent. of copper; but to be insignificant in amount.

10. *Iron.*—The ores of iron seem to be almost as small in amount at any one place as the copper ore just mentioned. Small balls or crystals of magnetic iron ore from the size of a walnut down, are found in a pebble rock at Aluggud through a small space; and similar bits of iron are found on the surface of the ground at Gunda, and doubtless in many other places. But no place has been found to yield enough to work.

11. *Lead.*—Galena is found in small crystals in a limestone near the Keora salt mines; but is in such small quantity as to be worthless.

VI. MAP.

The Topography of the map that goes with this paper is based on that of Captain (now Colonel) D. G. Robinson's admirable map of the Kohistan of the Sind Sagur Doab, a map on a scale of one mile to the inch with the steepness of the slopes shown merely by depth of shading, and with numerous levels marked in feet.

As a difference will be noticed in the spelling of the same names in the paper and on its map, it may be said that the spelling of the map is according to the rules of romanized Hindoostanee (or for reducing Hindoostanee to Roman characters), a system very convenient for maps, as comparatively brief, and showing the native pronunciation very perfectly, while the diacritical marks can be made in the manuscript without trouble. On the other hand the spelling of the names in the paper is according to the rules for anglicising Indian names, and is more convenient to print, from the absence of diacritical marks, and is more consistent with the rest of the text, and at the same time shows passably the common English pronunciation of native words.

The map is printed from a plate electrotyped direct from a photograph of the manuscript by the process of Mr. Julius Bien, Superintendent of the New York Lithographing, Engraving and Printing Company.

A GEOLOGICAL AND TOPOGRAPHICAL SKETCH MAP OF THE PANJĀB OIL REGION,

BY BENJAMIN SMITH LYMAN, FOR THE PUBLIC WORKS DEPT., GOVT. OF INDIA. OCT. 1871.

ROUGH SECTION OF ROCKS

NEWER ROCKS

FT. TRAVERTIN
S'ND & P'BLE R'C
135 (OLD ALLUVIUM

OLDER ROCKS

FT. SIWĀLIK?
100 S'FT GR'Y S'ND R'C
NUMMULITI

RED AND GREE
GR'Y CLAYS, WIT
SAND & PEBBL
ROCK LAYERS.

800 CO'RSE PEBBLE F
840 SANDY LIME R'K.
880 ĀLAGAD OIL
S'FT GR'Y S'ND R'K.
980

BR'N & GR'Y SHALS.
1150

GRAY SAND R'C
WITH A FEW LA
ERS OF PEBBL
ROCK, DARK RE
SHALES & GRA
SHALES.

DUMA, HANGŪ
1850 CHINNUR (SĀ
ĀLĪ?) TAR.
CHHOṬĀ KAṬ
BAṚA KAṬṬA C

BLUE GRAY LI
ROCK WITH NU
MULITES.

DALLA OIL.

RATA OTUR O

PANOBA OIL.

2950

1000? THE GANDA G
IS PERHAPS
TOP OF JĀBA

RED SAND RO
AND SHALES

1450 GANDA OIL.

1550 BR'N S'ND R. U
WITH NUM'LIT
BORĀRĪ OIL
CHHARAT O

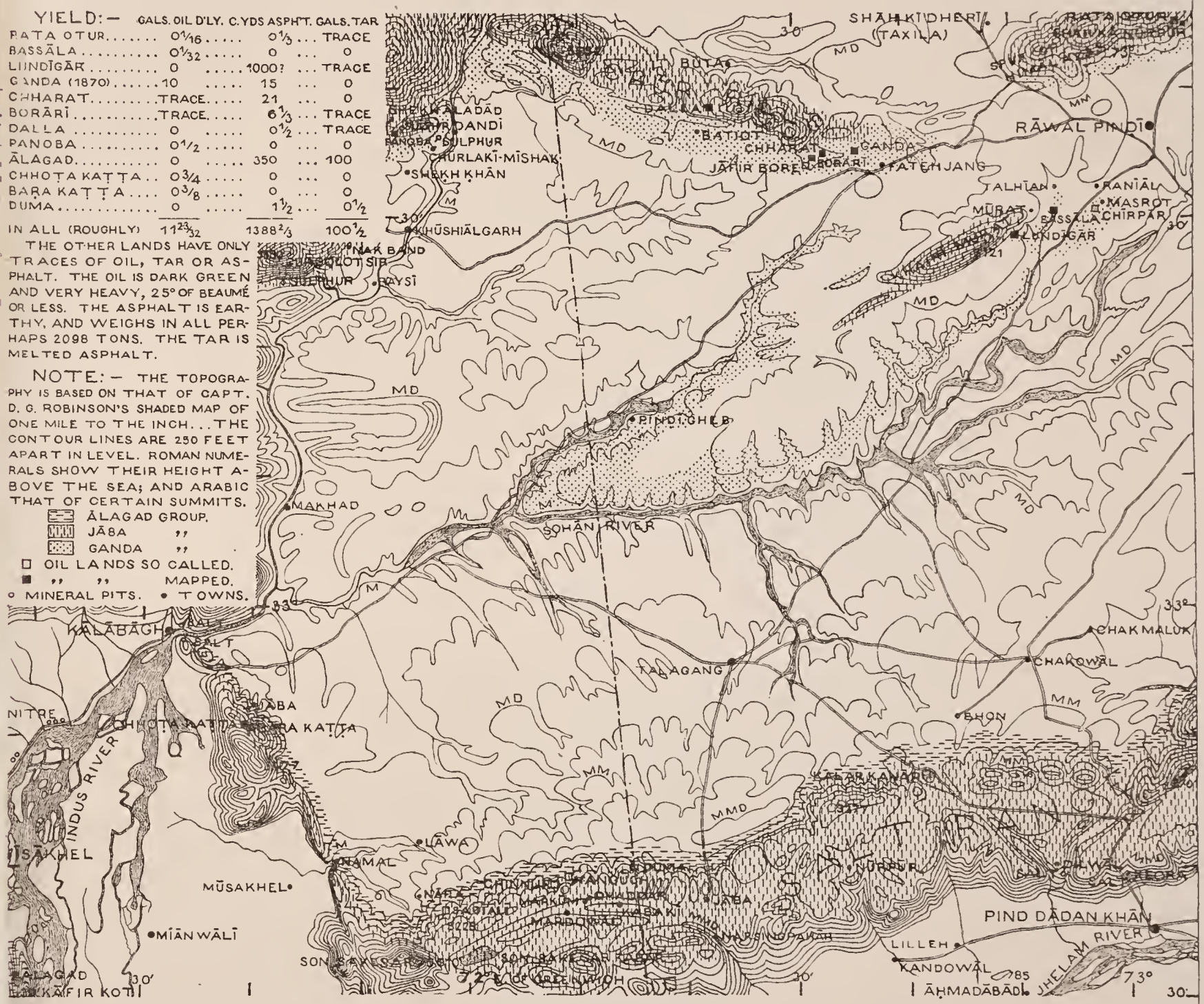
1740 GR'Y LIME R U
1800 RED SH'S. S A

YIELD:—	GALS. OIL D'LY.	C. YDS ASPH'T.	GALS. TAR
RATA OTUR	$0\frac{1}{16}$	$0\frac{1}{3}$	TRACE
BASSĀLA	$0\frac{1}{32}$	0	0
LUNDĪGĀR	0	1000?	TRACE
GANDA (1870)	10	15	0
CHHARAT	TRACE.	21	0
BORĀRĪ	TRACE.	$6\frac{1}{3}$	TRACE
DALLA	0	$0\frac{1}{2}$	TRACE
PANOBA	$0\frac{1}{2}$	0	0
ĀLAGAD	0	350	100
CHHOṬA KAṬṬA	$0\frac{3}{4}$	0	0
BAṚA KAṬṬA	$0\frac{3}{8}$	0	0
DUMA	0	$1\frac{1}{2}$	$0\frac{1}{2}$
IN ALL (ROUGHLY)	$11\frac{23}{32}$	$1388\frac{2}{3}$	$100\frac{1}{2}$

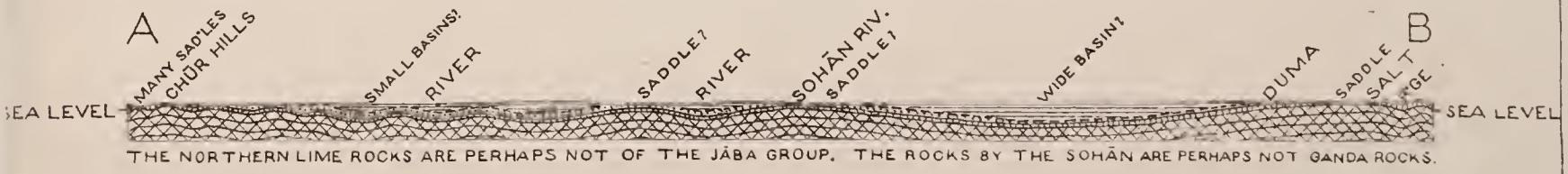
THE OTHER LANDS HAVE ONLY TRACES OF OIL, TAR OR ASPHALT. THE OIL IS DARK GREEN AND VERY HEAVY, 25° OF BEAUMÉ OR LESS. THE ASPHALT IS EARTHY, AND WEIGHS IN ALL PERHAPS 2098 TONS. THE TAR IS MELTED ASPHALT.

NOTE:— THE TOPOGRAPHY IS BASED ON THAT OF CAPT. D. G. ROBINSON'S SHADED MAP OF ONE MILE TO THE INCH... THE CONTOUR LINES ARE 250 FEET APART IN LEVEL. ROMAN NUMERALS SHOW THEIR HEIGHT ABOVE THE SEA; AND ARABIC THAT OF CERTAIN SUMMITS.

- ĀLAGAD GROUP.
- JĀBA ,,
- GANDA ,,
- □ OIL LANDS SO CALLED.
- ■ ,, ,, MAPPED.
- ○ MINERAL PITS. • TOWNS.



SECTION ACROSS THE BASINS IN THE LINE A B.



THE NORTHERN LIME ROCKS ARE PERHAPS NOT OF THE JĀBA GROUP. THE ROCKS BY THE SOHĀN ARE PERHAPS NOT GANDA ROCKS.

SCALE: $\frac{1}{900\,000}$ OF NATURE; OR 75000 FEET (=14 $\frac{1}{5}$ MILES) TO AN INCH.

0 5 MILES. 10 M. 20 M. 30 M. 40 M. 50 M. 60 M. 70 M. 80 M 90 M. 100 M
25 KILOMETRES. 50 K. 75 K. 100 K. 125 K. 150 KILOMETRES.